

Article

# Food Security in the Context of Liquid Biofuels Production

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**Abstract:** A crucial factor that determines the development of production and consumption markets for biofuels is the choice of raw materials that can ensure the highest possible production efficiency, the lowest cost and the smallest emission of harmful substances to the atmosphere during all production stages. Considerations underlying the development of biofuel production have been discussed as well as the theoretical mechanisms linking the generation of biofuels to the level of production and the variability of prices of agricultural raw products. The aim of this study has been to identify the scale at which energy raw materials originating from agriculture are used for liquid biofuels production and to explore their impact on food security. The study used public statistical data (OECD-FAO and IndexMundi). The time span of the analysis was from 2005 to 2018. First-generation biofuels based on food raw materials (cereal grains, root crops, sugarcane and vegetable oils) are becoming increasingly competitive with food production recent years have been a period of the dynamic growth in production of liquid biofuels. In 2018, the global production of these substances reached 167.9 billion litres (bioethanol and biodiesel together), consuming 16.1% of maize grain, 1.7% of wheat grain, 3.3% of grain of other feed grains and 13.5% of vegetable oil.

**Keywords:** food security; biomass; biodiesel; bioethanol renewable feedstocks; farm to fork

## 1. Introduction

Fossil fuels still remain the basic source of energy. It can be claimed with a high degree of probability that fossil fuels are responsible for considerable amounts of emission to the atmosphere, including GHG (greenhouse gases) [1]. According to European Environment Agency (EEA) [2], the chief sector causing emission of pollutants to the air in Europe is road, air, rail and water transport. The growth in motor transport worldwide has led to a rapid increase in the demand for fuels, especially derived from crude oil. Elevated emission of greenhouse gases is caused by the combustion of fossil fuels and changes in land use due to human activity [3,4]. Hence, alternative solutions are being searched for, especially biofuels that could actually compete with conventional energy carriers [5–15].

Biofuels have entered the market as an option intended to diminish the dependence on crude oil with its high and unstable prices, but also as a way to strive towards sustainable social, economic and environmental development [16].

Biomass is particularly important in providing raw materials for the production of renewable energy sources. The term biomass refers to all organic matter in the biosphere, of both plant and animal origin, and to materials obtained by its natural or artificial conversion [17–19]. By submitting biomass to biochemical, thermochemical and biological conversion processes, liquid and gas fuels are obtained (bioethanol, biodiesel, biogas). Up to now, biofuels have been produced mainly through alcohol fermentation of starch products (ethanol), municipal waste, sewage sludge and others (biogas), dry distillation of wood (methanol) and transesterification of higher fatty acids (biodiesel). Such fuels are counted as the first-generation ones and it is predicted that they will dominate for many years to come because they can be burnt in existing unmodified engines and their production is easy and economically viable. Currently, there are attempts to implement other renewable raw products in biofuel production, like cellulose, which are much more difficult to process, and to design more complex biotechnological methods [20,21].

Estimates show that nearly 700 million people around the world suffer from the shortage of healthy food. Food security, that is the necessity to ensure continuous access to food, is a basic human need. The most frequently cited definition of food security was formulated at the World Food Summit in 1996. The Food and Agriculture Organization (FAO) states that food security is achieved when all people and throughout all the time have physical, social and economic access to sufficient amounts of safe and nutritious food, which meets their food demand, satisfies preferences, and allows them to lead an active and healthy lifestyle [22]. Food security can be analysed at various levels (individual or family security, more often referred to as household food security, national food security as well as international or global food security) [23,24]. All dimensions of food security are closely interrelated. Food security is underpinned by food systems that link the food chain activities of producing, distributing and consuming food to a range of social and environmental contexts [22]. Full food security can only be ascertained if it is guaranteed simultaneously in all four dimensions: physical availability, economic accessibility, nutritional quality and long-term stability of these three dimensions [25]. Tirado et al. [26] presented four dimensions of food security, which resemble the ones cited above: food availability, where a sufficient amount of food of required quality delivered by domestic agricultural producers is available; food access, which guarantees that each individual is able to purchase food that satisfies their food needs (in this case, consumers' incomes as well as prices of food products and other goods and services matter as well); food utilization, which reflects the capability of effectively using food, to satisfy food requirements, and to have access to clean water and appropriate sanitary conditions and health care, and finally food stability, which refers to all the aforementioned dimensions and the time of their duration.

Until this year, the broadly accepted conceptualization of food security and nutrition had comprised only the four components mentioned above. On 25 June 2020, the High Level Panel of Experts (HLPE) issued the 15th report of food security and nutrition, commissioned by the UN Committee on World Food Security (CFS) [27]. In it, the concept of food security was expanded to comprise two other elements: agency and sustainability. Agency is the capability of individuals or groups of individuals to make own decisions regarding the food they consume or produce, how this food is produced, processed and distributed through food distribution channels, and their capacity to engage in processes which shape the food security policy and governance. Sustainable development expressed a long-term ability of systems to ensure food security and nutrition in a way that does not undermine the economic, social or environmental foundations, and which will provide food security and nutrition for future generations [28].

The farm-to-fork strategy (F2F) is an innovative complex approach, which proves that the EU appreciates sustainable food economy [29]. The formation of a proper food environment, where it will be easier to choose healthy and sustainable nutrition, will generate benefits for the health and quality

of life of food consumers while reducing the health care costs borne by entire communities. Nowadays, consumers are paying more and more attention to environmental, health, social and ethical aspects of goods, and expect to find such qualities in food products more adamantly than they did before. Societies wish to have access to fresh food, less processed food and food that is produced sustainably. Consumers should be given a chance to select sustainable food products. Production, processing, retail sale, packaging, and food transport contribute considerably to the contamination of air, soil and water and to the emission of greenhouse gases. In addition, they strongly affect biological diversity.

The European Climate Law [30] set a target of achieving EU's climate neutrality by the year 2050. A new approach was therefore developed within the F2F strategy to ensure that agriculture should give an appropriate contribution to the reduction of GHG emission. A sustainable food system will be fundamental to the attainment of the climate and environmental objectives set under the umbrella of the Green Order. The system of sustainable food must supply the human population with a sufficient and varied range of safe, good quality and economically available sustainable food products all the time, especially during a crisis.

Nevertheless, if some of the soil resources are occupied by energy plant fields, the potential for food production is weakened, which may result in rising food prices. It is expected that agriculture will continue to improve its productivity so as to satisfy the demand for food stimulated by the predicted population living in the mid-21st century, i.e., 9 billion people. [31]. Competition for agricultural resources entails competing for land and water, for consumption of fertilizers, pesticides, agricultural machines, labour, capital and others. Indirect land use change means that natural ecosystems might be turned into farmland in order to set up plantations of crops (animal fodder or food production) which have been lost somewhere else due to the production of biofuels [32].

In 2008, FAO informed that the rapidly growing demand for biofuel raw materials had caused an increase in food prices, which were then a direct threat to the food security of poor net food buyers (in terms of value), in both urban and rural areas. The increasing acreage of farmland dedicated to energy crops and the growing demand for raw materials to make biofuels are accompanied by a considerable rise in food prices and limited production of food. Competition between energy crops and crops grown for food evokes such consequences as the rapidly growing prices for food and food deficit on a global scale [33]. Higher food prices are due to several reasons. However, the strongest impact on increasing food prices is attributed to biofuels [34].

The aim of this study has been to identify the scale on which energy raw materials originating from agriculture are used for liquid biofuels production, and to explore their impact on food security.

## 2. Materials and Methods

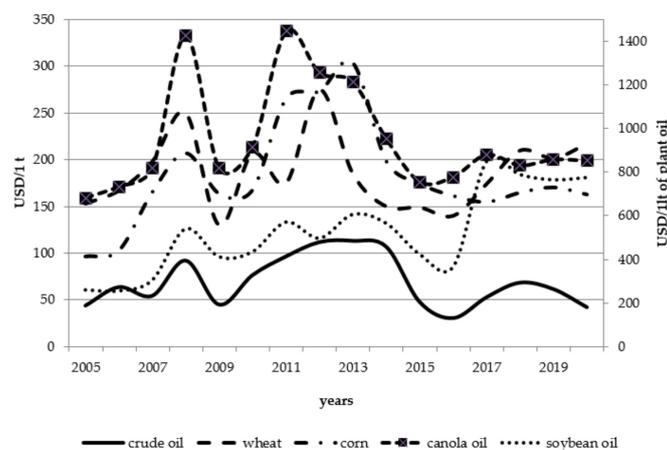
An attempt has been made to identify institutional conditions of biofuel production in the world, in addition to which trends in global prices for agricultural raw products have been analysed alongside implications arising from these prices to selected instruments supporting production of biofuels. This article contains a review of the subject literature, including data from publications concerning economy and agriculture, markets of agricultural products and biofuels, and relationships between them. Furthermore, the article is supplemented by an empirical part, where publically available statistics (OECD-FAO Agricultural Outlook [35] and IndexMundi [36]) are analysed. The above databases were selected because they are the source of approved and reliable statistical information. The data included in the study concerned the production of bioethanol and biodiesel, production, stocks and use for bioethanol of such plant products as grains of wheat, maize, fodder cereals, sugar beet and sugar cane, as well as the use of vegetable oils for production of biodiesel. The study spanned the years 2005–2018 (2018 estimate data). The upper threshold was defined by the availability of statistical data, whereas the lower one marked a rapid development of the production of liquid biofuels from agricultural raw products. The analyses include structure and dynamics indicators. Special attention has been paid to food security on an international scale.

### 3. Results and Discussion

First-generation biofuels are made from agricultural products mainly dedicated to food and feed purposes. For many years now, a belief has been held that such biofuels compete with food production, having an adverse impact on food prices, thereby contributing to the growing problem of famine in the world. In 2006–2008, production of biofuels was mentioned as one of the major factors responsible for food crises. However, in more recent years, there have been reports in which biofuels are ascribed a lesser role than previously in the negative influence on prices of agricultural products [37,38].

According to Simon [39], the author of the book *The Ultimate Resource*, the principles of demand and supply function like a natural mechanism. A decrease in the resources of any material entails an increase in its price, which in turn becomes an incentive to find new sources of this material (e.g., extraction of crude oil from increasingly deeper deposits) or to design innovations which aim to replace it with alternative materials (e.g., biodiesel and bioethanol in place of petroleum). Prices are the basic economic signals of ongoing or future changes in quantities and quality of food products. Price fluctuations reflect the stability of food security. High fluctuations or sudden changes in prices suggest drastic changes in food availability or accessibility. Nevertheless, the levels and changeability of prices are incomplete measures of food security because prices are both a result and a determinant of changes in the food market. Prices also represent depletion of household incomes per unit of expected quantity and quality of food. Thus, without some additional information, it is difficult to distinguish the impact of supply and demand factors on observed changes in food prices. Different reactions to changing food availability or accessibility may be associated with similar prices in the food market, but they have very different consequences for food security at a household level [38].

The ratio of oil prices to the prices of agricultural raw materials from which biofuels are produced is a basic indicator of their competitiveness. Dependences between petroleum prices and prices of agricultural products used for producing liquid biofuels are illustrated in Figure 1. Global prices of agricultural products are clearly connected with prices of crude oil. The principles of biofuel policy, having accepted high limits of the minimal share of biofuels in the early stage of initiating biofuel production, most probably led the market participants to believe that it would be difficult to supply sufficient quantities of biofuels to satisfy the demand. This was reflected by a high increase in prices in 2007–2008. In turn, the rapid increase of prices in 2011 was most probably caused by the unfavourable weather conditions, leading to crop failure and drastically lower yields harvested in Russia, Kazakhstan and Canada. Noteworthy is the fact that as petroleum prices go up, prices of wheat, maize, oilseed rape oil or soybean increase as well. This relationship may persist in the future.



**Figure 1.** Prices of crude oil and some agricultural raw materials used for the production of biocomponents. Source: own calculation based on <https://www.indexmundi.com>.

Globally, the market of agricultural products has been brought out of balance due to the development of the biofuels market since 2005, when the production of biofuels from agricultural raw

products rose considerably. Under the market conditions, the economic potential of using agricultural products to make biofuels is determined by a ratio between the price of a given raw material and the price of petroleum, and by conversion factors of particular types of raw material. When this ratio is high, there are no economic reasons why biofuels should be produced, and vice versa. The active role of a state has contributed to an increase in industrial demand, and price relations have not always justified a decision to use agricultural raw products to generate biofuels [40].

Regulations in the scope of biofuel policy stimulate the demand. On the other hand, they reduce its flexibility (e.g., a regulation setting the minimum contribution of admixtures). The demand for biofuels is rather inflexible because it cannot fall below the level defined by the mandatory minimum admixtures or increase above the limits dictated by the technological limitations of combustion engines. As a result, prices can increase much and their fluctuation under shock conditions (drought, flood or high overproduction) can be significant [41].

Relationships between prices of agricultural products and prices of crude oil can be considered in the context of levels of prices, but also in terms of variability transmission between prices. In this regard, a study by Serra et al. [42] confirms that the greater volatility on the petroleum market after the year 2005 was accompanied by higher fluctuations of prices of agricultural products.

The impact of the development of biofuel market is not restrained to the market of feedstocks. Competition for land and substitution dependences means that prices of other plant products which are used for biofuel production only to a very small extent, for example, wheat or rice, may increase at the same time. Furthermore, cost effects mean that as the prices of cereals and oil plants grow, the prices of animal fodders increase too, and this entails higher prices of animal products [43].

The following Figure 2 proves how many interactions can appear in the market of biofuels and food. The major reason behind such a wide range of mutual relationships is the difficulty in including all potential factors and links between them.

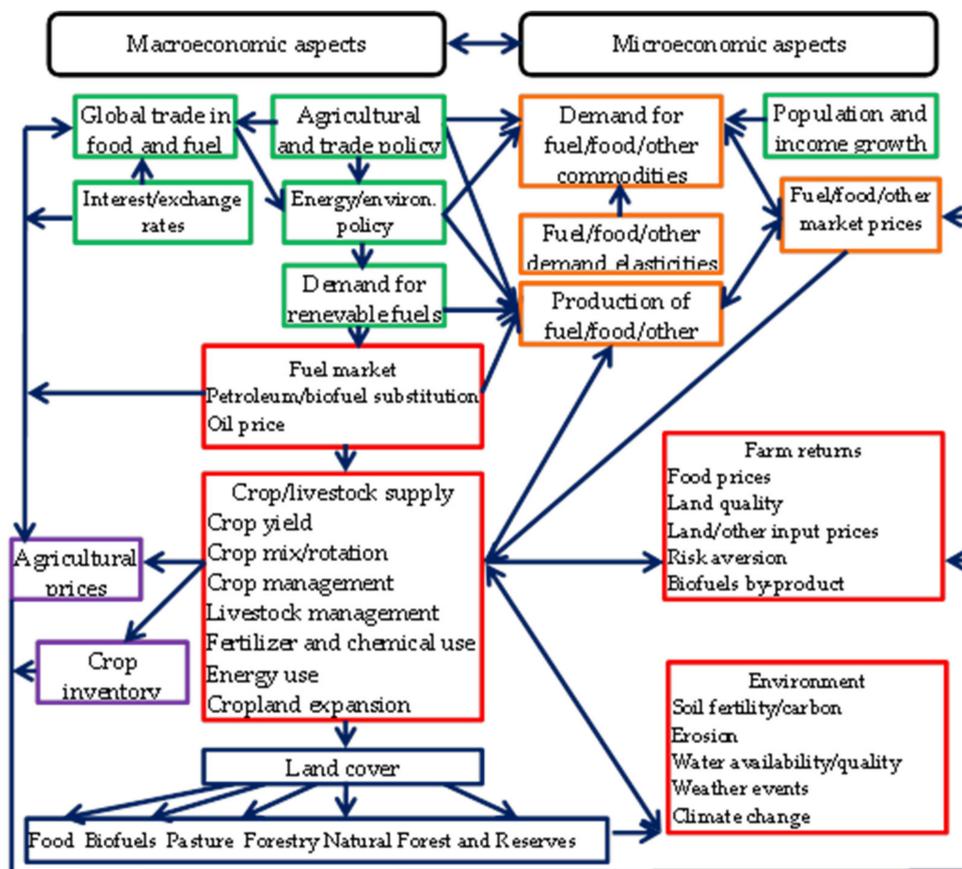


Figure 2. Biofuel-food market interactions. [38].

Concerns about energy security raised due to the global trade of fossil fuels are the primary motivation behind the policy regulating biofuels. The dependence of national economies on the increasingly volatile markets of crude oil and the unpredictable geopolitical situation may cause supply disturbances, prompting the search for more reliable energy sources. Consequently, decision-makers (including the European Parliament and the EU Council, Brussels, Belgium) issue directives on the production and use of renewable energy sources, in this case biofuels, thereby combining agricultural, trade, energy and environmental policies. The implementation of the biofuel policy, which stems from the above developments, leads to direct interactions between biofuels and food on the crops and land markets [38].

One of the major factors which can distort supplies of raw materials for the generation of biofuels is the occurrence of such unpredictable weather events as droughts or floods. Other risk areas are changes in the policy governing the trade of agricultural products or in the biofuel support policy (as was the case in 2006–2008), which may cause disturbances in the global market of raw materials for biofuels. An example is the global increase in prices of agricultural products in 2006–2008, which coincided with a sudden rise in the production of biofuels, in addition to which there were large losses in crops caused by unfavourable weather conditions. Moreover, the economic situation, including volatile interest rates, currency exchange rates or an increase in incomes, can alter the competitive position of global suppliers of agricultural products and consumers, thereby affecting their ability to balance supplies and demand. Agriculture is characterized by the seasonality of production, which means that maintaining a register of crops plays an important role in responding to any fluctuations in supply and demand in agricultural raw materials markets. The availability of stocks of plant resources during their low supply periods or the capacity to store such materials during their oversupply might mitigate the price effects of supply-demand fluctuations [38].

Production of biofuels can also affect food markets via other channels. The intended purpose of biofuels is to replace some of the crude oil used nowadays, which is expected to decrease the consumption and prices of petroleum. Countries which consume large amounts of crude oil can allocate the savings from lower crude oil prices to purchase fuels and other commodities, and to offset at least some or all of the increase in food prices. The effect of biofuels on the price of crude oil would also have an indirect effect on agricultural production, by lowering the inputs allocated to fuels, which would reduce agricultural fuel consumption. Similarly, biofuel by-products could mitigate the impact of biofuels on food markets. For instance, around a third of corn yields dedicated to the production of ethanol in the USA is returned as dried grain distillers with soluble substances (DDGS), which are a high-protein substitute of other animal fodders. For producers of agricultural products, an increase in prices can translate into higher profits of agricultural households [38].

However, Trostle [44], Mueller et al. [45] and Trostle et al. [46] were able to identify and limit their research to what they considered were the most significant drivers of change in the food market. These are: the growth in human population, increase in incomes, growing prices of energy, increasing costs of agricultural production, changes in the value of the US dollar, accumulation of foreign exchange reserves, loss of farmland to non-agricultural land uses, financial speculations in commodity markets, changes in agricultural and trade policies, decreasing preferences to keeping stocks in favour of just-in-time deliveries, unfavourable changes in the weather conditions, increasingly limited access to water for farming, potential yet still unclear effects of climate change.

### *3.1. Impact of Liquid Biofuels Production on the Market of Cereals and Vegetable Oils*

Our assessment of the impact of the biofuel sector on the market of plant raw materials was based on an analysis of the principal components of this market, including wheat, fodder cereals, and plant oil. The world production of liquid biofuels (bioethanol and biodiesel) has been growing dynamically. In 2005–2018, it nearly trebled (from 49.9 billion L to 167.9 billion L) (Table 1). For the past decade, there has been a nearly three-fold increase in bioethanol production and almost ten-fold increase in biodiesel production. Despite strong increasing tendencies on the global scale, the consumption of biofuels

remains small when compared with the global use of liquid fuels in transport. In 2014, the contribution of biofuels constituted just 4.9%.

**Table 1.** First generation biofuel production (billion L).

Specification	2005		2010		2015		2017		2018	
	UE	World								
Bioethanol										
Production	2.4	45.8	5.4	103.7	6.5	118.2	6.5	120.8	6.9	127.6
Dynamic (%)	100	100	225	226	271	258	271	264	288	279
Biodiesel										
Production	3.5	4.1	10.7	20.0	13.3	30.7	13.2	35.5	13.5	40.3
Dynamic (%)	100	100	306	488	380	749	377	866	386	983

Source: own calculation based on OECD-FAO Agricultural Outlook data.

Ethanol, also for energy purposes, can be obtained from any raw material which contains sugars or starch, for example sugarcane, cereal grains (mainly corn and wheat), sugar beet or potato. Currently, sugarcane and corn are the most important raw materials for bioethanol production. The former raw material is massively used in Brazil, and the latter one is popular in the USA, which are both major bioethanol producers in the world. In Europe, bioethanol is mainly produced from cereals and sugar beet. Until now, production of ethanol from these raw products has been very expensive. As the prices of raw materials dominate in the structure of production costs, the key importance in bioethanol production profitability is attached to having access to cheap agricultural products. In the few past years, production of bioethanol has been growing dynamically, exceeding 6.9 billion L in the EU (in 2018), while the global production reached 127.6 billion L. To achieve this output, 21.1% of the global cereal yields (wheat, fodder cereals, corn) and 16.3% of yields in the EU were processed for this purpose (Table 2). In 2005, much less of cereal grains was converted to bioethanol, namely 9.6% in the world and 5.4% in the EU.

Despite the growth in the production of wheat attained in the last decade, excess yields of this cereal have decreased, particularly in the EU countries. In the global balance, greater deficits have been caused by the growing demand for food purposes (higher by 69.2 M. tons). The increasing demand for food coexisting with the relatively low flexibility of agricultural production (in the short term) causes prices to increase. The increase in the demand for food is a consequence of the growing human population and the improving revenues of people in economically developing countries [47]. In the EU, consumption of wheat has remained almost unchanged (an increase by ca. 1.5 million tonnes). In the EU countries, however, the amounts of stored wheat grain have decreased from 25.6 to 9.9 million tonnes).

In 2018, relative to the 2005 season, the industrial consumption of wheat in the world increased by 170% (from 7.4 to 12.5 million tonnes), which corresponded to 1.2 and 1.7% of harvested yields, respectively. The industrial consumption of wheat grain, including the use for producing biofuels, affects the market of fodder cereals more than the wheat market. In this segment, the demand for grains to be processed to bioethanol has increased even more rapidly. In the UE countries, 5.4% of harvested fodder cereal grains were converted to bioethanol in 2005, in comparison with 16.3% in 2018. A very high dynamics of processing grains to bioethanol was noted in the European corn market (an increase from 1.8 million tonnes, i.e., 2.8% of harvested yields, in 2005 to 6.4 million tonnes, 10.3%, in 2018). In 2018, 21.1% of fodder cereal grains were processed to bioethanol (in 2005, only 9.6% of global yields of fodder cereals were dedicated to this purpose).

Production of bioethanol from sugar beet plays a small role due to such circumstances as high costs of sugar beet cultivation in Europe, with the resulting decline of 1.6 billion tonnes in production between 2005 and 2013. Overall, the sugar beet production in 2005–2013 was highly volatile. Despite

much lower yields, the use of this agricultural produce for energy purpose increased (from 8.6 to 13.1 b tonnes).

**Table 2.** Balance of raw feedstocks used for biofuel production.

Specification	2005		2010		2015		2017		2018	
	UE	World								
Wheat (M. tons)										
Production	120.9	626.9	122.4	652.6	144.5	737.2	137.7	761.3	124.9	734.0
Dynamic prod. (%)	100	100	101	104	120	118	114	121	103	117
Ending stocks	25.6	174.1	9.5	211.7	12.7	258.4	16.0	297.0	9.9	286.8
Dynamic (%)	100	100	37	122	50	148	63	171	39	165
Food	48.6	440.5	48.9	460.5	49.5	490.6	49.9	503.6	50.1	509.7
Dynamic (%)	100	100	101	105	102	111	103	114	103	116
Bioethanol use	1.8	7.4	4.1	11.5	4.6	12.3	4.5	12.3	5.1	12.5
Dynamic use (%)	100	100	228	155	256	166	250	166	283	170
% for bioethanol	1.5	1.2	3.3	1.8	3.2	1.7	3.3	1.6	4.1	1.7
Maize (M. tons)										
Production	65.0	716.1	59.9	869.7	59.3	1038.2	65.7	1114.8	62.1	1132.0
Dynamic (%)	100	100	92	121	91	145	101	156	96	158
Ending stocks	17.7	137.3	13.9	136.2	11.4	341.3	19.9	388.1	15.9	358.2
Food	3.9	105.6	4.5	117.9	4.4	129.1	4.4	134.0	4.4	137.0
Bioethanol use	1.8	51.3	4.1	148.7	6.4	169.4	6.4	179.9	6.4	181.7
Dynamic use (%)	100	100	228	290	356	330	356	351	356	354
% for bioethanol	2.8	7.2	6.8	17.1	10.8	16.3	9.7	16.1	10.3	16.1
Other cereals (M. tons)										
Production	79.9	279.3	78.0	272.3	86.2	299.9	83.5	292.5	78.8	284.9
Dynamic (%)	100	100	98	97	108	107	105	105	99	102
Ending stocks	14.2	54.7	13.4	59.8	13.9	60.4	6.5	52.8	5.6	53.0
Food	4.0	66.9	4.2	71.5	4.2	76.5	4.2	77.6	4.2	79.1
Bioethanol use	0.9	3.4	2.1	6.7	1.6	9.6	1.5	9.5	1.5	9.4
Dynamic use (%)	100	100	233	197	178	282	167	279	167	276
% for bioethanol	1.1	1.2	2.7	2.5	1.9	3.2	1.8	3.2	1.9	3.3
Sugar beet (M. tons)										
Production	128.3	248.6	98.5	228.1	95.8	245.3	134.4	311.1	110.7	281.6
Dynamic (%)	100	100	77	92	75	99	105	125	86	113
Bioethanol use	8.6	9.3	12.2	13.1	11.9	12.7	13.1	14.0	13.1	14.0
Dynamic use (%)	100	100	142	141	138	137	152	151	152	151
% for bioethanol	6.7	3.7	12.4	5.7	12.4	5.2	9.7	4.5	11.8	5.0
Sugar cane (M. tons)										
Production	0.0	1302.6	0.0	1572.7	0.0	1798.8	0.0	1754.9	0.0	1746.4
Dynamic (%)	100	100	129	125	144	147	147	165	138	169
Bioethanol use	0.0	176.5	0.0	325.9	0.0	368.3	0.0	338.3	0.0	397.4
Dynamic use (%)	0.0	100	0.0	185	0.0	209	0.0	192	0.0	225
% for bioethanol	0.0	13.5	0.0	20.7	0.0	20.5	0.0	19.3	0.0	22.8
Vegetable oil (M. tons)										
Production	10.3	123.3	13.3	153.6	14.8	180.7	15.1	203.7	14.2	207.8
Dynamic (%)	100	100	129	125	144	147	147	165	138	169
Ending stocks	0.9	12.3	1.1	20.4	1.4	22.1	0.9	23.3	0.9	21.4
Food	11.5	76.8	9.6	108.7	10.3	126.7	11.1	136.8	11.2	139.2
Biodiesel use	2.9	3.1	8.9	15.3	10.3	21.3	10.1	24.4	10.3	28.0
Dynamic use (%)	100	100	307	494	355	687	348	787	355	903
% for biodiesel	28.2	2.5	66.9	10.0	69.6	11.8	66.9	12.0	72.5	13.5

Source: own calculation based on OECD-FAO Agricultural Outlook data.

The global production of sugarcane increases steadily. Over the past several years, a significant contribution of technological advance has been observed in sugar cultivation, in addition to which sugarcane is now also used for the production of bioethanol in the fuels sector. The share of sugarcane in all crop producing fields is not high, but the cultivation of this plant is significant in the agriculture and economy of many subtropical countries. In the countries lying in the tropical or subtropical climate (Caribbean countries, like the Bahamas, Barbados, Martinique) and in the countries of Southeastern Africa (Suzazi) or on islands on the Southwestern Indian Ocean (Mauritius, Reunion), plantations of sugarcane correspond to 30%–70% of total cropped land. The dynamic of sugarcane production showed an increasing tendency, from 1.3 to 1.8 billion tonnes.

Biodiesel is the first-generation biofuel obtained in the process of esterification of fatty acids contained in plant oil or animal fat. Currently, global production of the first-generation biofuels used in high-pressure engines is based on soybean, oilseed rape and palm oils, in different proportions between these raw products in different parts of the world. The EU is the largest producer and consumer of biodiesel in the world. However, at the beginning of this decade, the increase in biodiesel production in the EU has been reduced. In Northern and Central Europe, where oilseed rape dominates, oilseed rape oil is mainly used for producing biodiesel. In the last 13 years, the share of vegetable oils in the production of biodiesel has risen considerably. In 2005, 2.5% of the world's production of vegetable oils was dedicated to biodiesel production, while in 2018 this contribution rose more than five-fold, to 13.5%. The EU countries noted an increase from 28.2 up to 72.5%.

### 3.2. Perspectives on First Generation Liquid Biofuels

The Directive 2009/28/WE specifies the criteria of sustainable development, including the necessity to protect areas of high biodiversity and areas rich in carbon, but does not address the issue of indirect land use change. Indirect land use change occurs when plantations of crops for the production of biofuels, bioliquids and biomass-based fuels displace traditional cultivation of crops for food and fodder. The directive of the European Parliament and Council (EU) 2015/1513 [48] recognizes that the scale of indirect land use change causing greenhouse gas emissions may offset some or all of the reduction in the GHG emissions attributed to particular biofuels, bioliquids or biomass-based fuels.

The highest risk of indirect land use change has been identified in terms of biofuels, bioliquids and biomass-based fuels produced from such raw materials obtained from the crops whose plantations have been observed to expand over carbon-rich soils. With the current development, knowledge and experience, the EU takes the view that further promotion of biofuels, bioliquids and biomass-based fuels from biomass of food and fodder plants, as envisaged by the said directive, should be restricted. This is particularly true about the crops whose plantations have covered areas rich in carbon. Biofuels, bioliquids and biomass-based fuels characterized by a low risk of causing indirect land use change should be released from the specific and gradually smaller limited quantities of allowed production [49].

The regulations included in the RED II Directive also presume that second-generation biofuels should play an increasingly important role. At least 14% of fuels used in transport should originate from renewable energy sources by the year 2030; however, first-generation biofuels, burdened with 'a high risk of causing indirect land use change', will no longer be considered RES (renewable energy sources) for the purposes established in the EU law. The share of first generation biofuels in the achievement of the above targets was expected to start decreasing in 2019 and continue to decline until reaching the zero level in 2030. The implementation of the RED II Directive aims to achieve the new EU target where the share of RES in the EU energy mix should reach at least 32% until the year 2030. The adopted guidelines for the EU energy management are to guarantee that every country will be gradually increasing the share of renewable energy in their energy mix [48]. Despite the constant progress of the RES sector in Poland, their share in the energy mix is still far from being sufficient (14.1% in 2017) to meet the norms adopted by the EU [50].

In order to prepare the process of conversion to advanced biofuels and to minimize general effects of direct and indirect land use change, it is necessary to limit the quantities of biofuels and bioliquids

produced from cereals and from other starch-rich plants, from sugars and oil plants. This can be seen as a way to meet the targets specified in the RED II Directive without restricting overall opportunities of using such biofuels and bioliquids. Biofuels, bioliquids and biomass-based fuels should always be produced in a sustainable way. Biofuels, bioliquids and biomass-based fuels that are used in order to achieve the EU aims defined in the above directive and the ones that are financed from support programmes should therefore satisfy the criteria of sustainable development and reduction of greenhouse gas emission. Harmonization of these criteria for biofuels and bioliquids is pivotal to the attainment of the objectives of the energy policy, as specified in Article 194 paragraph 1 of TFEU [51].

Energy security of any country means this country needs to ensure supplies of adequate amounts of electric power at a price its recipients are able to pay, while simultaneously adhering to the principles of nature conservation and protection. The European Union is of the opinion that effective reduction of CO<sub>2</sub> emission calls for the development of second generation biofuels (produced from lignocellulose feedstocks). The essence of second generation biofuels is to use waste materials, useless for production of food. Another significant distinction from first-generation biofuels is higher quality of second-generation biofuels, which makes them more readily acceptable by the automotive industry and drivers.

New technologies enable us to use cellulose biomass to make ethyl alcohol. By analogy to the definition of first generation bioethanol, bioethanol produced from lignocellulose is termed second-generation bioethanol or cellulose ethanol [52]. The technology for producing ethanol from cellulose containing biomass has raised interest among researchers [53–55]. To achieve competitive costs and increase production output, supplies of cheap raw products are necessary. Cellulose biomass of lignocellulose is considered to be the most promising raw product for bioethanol production owing to its availability, low cost and the fact that it does not compete with food production, the same as sugar/starch materials. However, it should be borne in mind that conversion of cellulose biomass to ethanol is more difficult than from sugar/starch feedstocks [56].

Experts claim that cellulose ethanol, if produced from low-input cellulose grown on grassland or on marginal land or derived from waste biomass, can ensure much bigger energy supplies and environmental benefits than biofuels based on food raw products [57,58]. It needs to be emphasized, however, that the use of post-harvest residues or agricultural ‘waste’ is debatable. Some authors maintain [59,60] that there is no ‘waste’ in agricultural ecosystems. By-products and post-harvest residues play a very important role in maintaining soil fertility, providing sources of organic matter and other soil-fertility improvement substances. Regular collection of post-harvest residues can cause soil erosion [61], which is detrimental to agriculture. Removal of corn residues in corn agricultural ecosystems in the USA has led to a substantial decline in corn yields and deteriorated soil properties [62,63], in addition to which it has contributed to an overall increase in GHG emission [64]. The above are all reasons why lignocellulose biomass (second generation) is an alternative raw product for bioethanol production. Lignocellulose biomass is inexpensive, widely available, and not competitive towards food or feed production [65]. Being an inexpensive and low-cost substance, lignocellulose is the most promising feedstock [66,67]. Perennial plants can be especially useful [68].

Use of edible oils as first-generation raw materials raises serious doubts whether this is a reasonable solution. Hence, it is worth considering the use of non-edible plant oils, as its edible counterpart is a much sought-after foodstuff [69]. The most important arguments in favour of using non-edible oils for production of biodiesel are: non-edible oil plants can be easily cultivated on soils unsuitable for the cultivation of food crops, and the costs of such plantations are much lower than those of growing edible oil plants [70], in addition to which fields of these plants contribute to a decrease in atmospheric CO<sub>2</sub>. A wide range of raw materials representing non-edible oils is one of the crucial factors motivating the production of biodiesel. Furthermore, the use of non-edible oils, an economically profitable solution, can be a way to improve the economics of biodiesel production and its commercial generation on an industrial scale [71].

Selection of an appropriate raw material is pivotal for ensuring low costs of biodiesel production. Any raw material for the generation of biodiesel should satisfy two crucial criteria: low costs of production and a potential for large-scale production [72]. There is a wide range of raw materials for biodiesel production (other than edible vegetable oils used to make first generation biofuels), including oil from jatropha, karanja, mahua, flaxseed, cotton seed, Indian honey, camelina, etc., as well as waste or recycled oils, e.g., waste cooking oil, animal fats or fish oil by-products [73]. Out of all these oils, non-edible vegetable oils, waste oils or recycled oils, and also animal fats, are considered to be suitable raw materials for second-generation biodiesel. To improve the economic effectiveness and improve the conversion technology in order to attain sustainable production, it is necessary to support further research [74].

#### 4. Conclusions

The F2F strategy is a starting point for a coherent, harmonized and sustainable food system in the entire European Union. Within this strategy, the Council identified three main targets for the member states: to ensure sufficient amounts of food at reasonable prices, to contribute to the EU's climate neutrality until 2050 and to guarantee decent incomes and strong support to food producers. The Commission presented the F2F strategy in May 2020, emphasizing that it is an integral component of the EU Green Deal, where one of the objectives is to make a just, healthy and eco-friendly food system.

The current state of knowledge implicates that biofuels are not a panacea for energy supply problems, free from leading to other serious social and environmental difficulties. Instead, they can undermine the food security of billions of people, and may even add to the emission of greenhouse gases. Widespread use of biofuels necessitates a broader range of non-food raw materials (lignocellulose biomass) and advanced conversion technologies to be implemented in bioethanol and biodiesel production. Regarding ecofriendly energy generation, one needs to consider how to generate more and more energy whilst causing the least possible harm to nature. One of the ways of producing clean energy is energy farming. Agricultural production of energy crops was hoped to create a firm base for sustainable profitability of agricultural production, where potential farm produce could be sold in two important, large markets: the food market and the energy market. This might substantially intensify agricultural production for non-food purposes, which in turn could induce several, nearly unpredictable, consequences in the natural environment.

In this new reality, agriculture is no longer a provider of food but also a supplier of biomass for energy purposes. Due to its distributed character and use of local resources, a renewable source of energy can serve as an element which to some extent can improve the country's energy security.

The world production of liquid biofuels (bioethanol and biodiesel) is growing dynamically. In 2005–2018, it increased almost threefold (from 49.9 billion L to 167.9 billion L). The increase in wheat production has not result in any increase in the final stocks of this cereal; on the contrary, there was a decline, particularly in the EU countries (from 25.6 million tonnes to 9.9 million tonnes). Very high dynamics of grain conversion into bioethanol were also noted in the European corn market. In 2018, 13.5% of global vegetable oil production was allocated to energy purposes (a five-fold increase compared to 2005). Similarly, in the EU, the growth reached 72.5%.

There is an urgent need to conduct studies and make analyses concerning the competition between biofuels made from agricultural raw products and food security. Production of biodiesel from food oils is not a beneficial solution as it can stimulate an increase in food prices while simultaneously more farmland is occupied for production of energy crops. In the nearest future, it is recommendable to diversify raw materials used for production of liquid biofuels. It is absolutely necessary to shift from making biofuels based on cereals to producing biofuels from non-food raw materials (using non-food substances, e.g., cellulose). It is often assumed that production of biofuels based on cellulose cannot have a serious impact on food security (probably because of the low consumption of raw products). However, it is not only the use of agricultural raw products to make biofuels, but also the production of cellulose-based biofuels that can compete with the demand for food and for agricultural resources.

It is necessary to develop more efficient and less expensive technologies of generating bioethanol from non-food raw materials, especially based on cellulose (such as woody biomass, straw from cereal crops from energy crops), and even from algae. Both proponents and critics of biofuels agree that the Earth's land resources are insufficient to produce large quantities of energy crops without causing a serious impact on the global food products. Ethanol is currently used all over the world on a broad scale, which is why its production should be cost-effective and friendly to the environment.

Biodiesel from renewable resources brings about many environmental benefits, owing to which it can become an alternative fuel. In fact, the major obstacles to its commercialization are its cost and unavailability in large amounts. The cost of raw materials and processing cost are the major contributors to the increased biodiesel production costs, which hinder the commercial growth of biodiesel manufacturing in comparison with conventional diesel oil.

Biofuels, bioliquids and biomass-based fuels should always be produced respecting the principles of sustainability. The biofuels, bioliquids and biomass-based fuels that are used to achieve the EU's targets, including ones which are supported through funds, should therefore meet the criteria of sustainable development and reduced GHG emission. Production of agricultural raw materials for the purpose of generating biofuels, bioliquids and biomass-based fuels should not threaten in any way areas distinguished by large biological diversity.

One of the principal advantages of biomass as a raw product in biorefinery processes is its availability. The present pre-treatment techniques ought to be improved to make the second generation biofuels more economically viable.

Nevertheless, it needs to be emphasized that first and foremost agriculture should produce an adequate amount of a given raw product which will be dedicated to food and fodder purposes. Thus, it is only the remaining areas of farmland that could be used for other purposes, including cultivation of energy crops. Many countries have limited farmland resources, which are being gradually diminished.

Nowadays, interdisciplinary research is needed on the use of biomass for energy purposes, especially in areas where agricultural and energy sciences merge, but also inclusive of economics in order to capture the analysed issues comprehensively and to monitor their various consequences. Currently, production of biofuels (especially first generation liquid ones—bioethanol and biodiesel) gives rise to a genuine conflict between food and energy production. To relieve this tension, it is essential to implement available and develop new technologies for converting agricultural biomass into energy, especially such biomass whose cultivation does not compete with food production.

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